executive briefing

Technology Strategy Board
Driving Innovation

aim RESEARCH
Advanced Institute of Management Research

High Value Manufacturing

Delivering on the Promise

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EPSRC
Engineering and Physical Sciences Research Council

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

AIM – the UK's research initiative on management

The Advanced Institute of Management Research (AIM) develops UK-based world-class management research. AIM seeks to identify ways to enhance the competitiveness of the UK economy and its infrastructure through research into management and organisational performance in both the private and public sectors.

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about AIM

AIM consists of:

- Over 250 AIM Fellows and Scholars – all leading academics in their fields…
- Working in cooperation with leading international academics and specialists as well as UK policymakers and business leaders…
- Undertaking a wide range of collaborative research projects on management…
- Disseminating ideas and shared learning through publications, reports, workshops and events…
- Fostering new ways of working more effectively with managers and policymakers…
- To enhance UK competitiveness and productivity.

AIM's Objectives

Our mission is to significantly increase the contribution of and future capacity for world class UK management research.

Our more specific objectives are to:

- Conduct research that will identify actions to enhance the UK's international competitiveness
- Raise the quality and international standing of UK research on management
- Expand the size and capacity of the active UK research base on management
- Engage with practitioners and other users of research within and beyond the UK as co-producers of knowledge about management

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AIM research themes

Current AIM research projects focus on:

UK productivity and performance for the 21st century

For management research to have a central role in increasing productivity and performance, it must be guided by the needs of practitioners. Our Business Engagement projects engage with the current and future issues faced by UK managers. Interviews with leading practitioners enable us to establish industry's priorities, which we then use to guide and influence our future research agenda.

Sustaining innovation to achieve competitive advantage and high quality services

All managers operate in a competitive environment, and innovations such as new strategies, products, services and organisational processes are key sources of competitive advantage and public value. The UK has outstanding innovative private and public sector organisations and AIM researchers are working with UK managers in order to support future innovative capacity.

Adapting promising practices to enhance performance across varied organisational contexts

Improved management practices are important for enhancing productivity and performance so it is vital that new and beneficial knowledge is shared across sectors. AIM researchers systemically address the evidence behind good and promising practices, establishing how they can be systematically assessed, creatively adapted and successfully implemented.

executive review

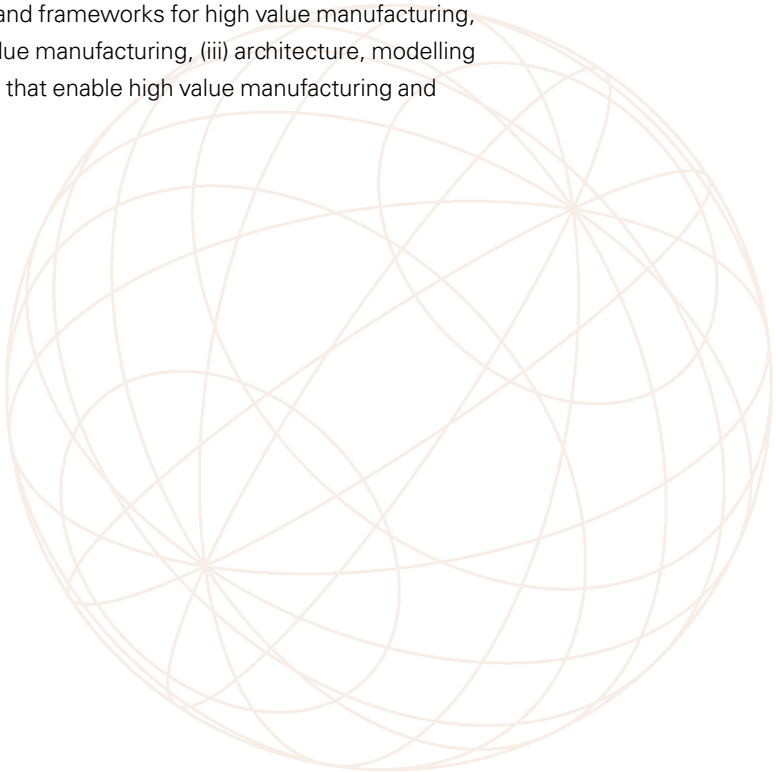
This report was produced following a high value manufacturing workshop involving a range of academics, practitioners and policymakers organised by AIM Research and the Technology Strategy Board. The purpose of the discussion was to explore what high value manufacturing meant to UK manufacturers, especially in the context of global value systems – networks of organisations cooperating internationally to create and deliver value to their stakeholders. A secondary aim of the discussion was to identify how the Technology Strategy Board – and its partners – might support practical and applied work to help UK manufacturing firms realise the vision of high value manufacturing.

The purpose of the discussion was to explore what high value manufacturing meant to UK manufacturers, especially in the context of global value systems…

Based on inputs gathered during the discussion and subsequent analysis this report defines high value manufacturers as *manufacturing firms that do not compete primarily on cost. Instead they deliver value for one or more of their stakeholder groups by contracting for capability, delivering product/service innovation, establishing process excellence, achieving high brand recognition and/or contributing to a sustainable society*.

The Technology Strategy Board identifies four pillars that help firms achieve these ends – products, manufacturing processes, service systems and global value systems. The view of the workshop participants was that the Technology Strategy Board already supports a great deal of work on the first two of these pillars – products and production processes – and that to create the right environment for UK manufacturing firms to compete internationally more work was needed on the second two pillars – service systems and global value systems.

Drawing on the workshop discussions this report recommends that the Technology Strategy Board and its partners, the Economic and Social Research Council (ESRC) and the Engineering and Physical Sciences Research Council (EPSRC) look for ways of enhancing our understanding of high value manufacturing in an era of globalisation in four main areas: (i) evolving context and frameworks for high value manufacturing, (ii) strategies and measures for high value manufacturing, (iii) architecture, modelling and design of the global value systems that enable high value manufacturing and (iv) skills for high value manufacturing.



Under these broad headings, specific sub-questions are proposed:

1 Evolving Context and Frameworks for High Value Manufacturing:

- High value manufacturers operate in a dynamic competitive environment, but often firms are constrained by legacy systems, structures and relationships – including those introduced by external actors such as regulators and legislators. Understanding how the global competitive environment that UK manufacturers face will change and what the implications of these changes will be is essential.
- Given increasing concerns about environmental pressures on the planet's resources, how can high value manufacturing and the associated global value systems best contribute to a sustainable society?
- Current research raises questions about how profitable the shift to services is for high value manufacturing firms. A series of macro and micro studies have highlighted that it is more difficult to achieve higher profitability through services than might originally be assumed. What is the appropriate balance for high value manufacturing firms between revenues from services and revenues from production? What practical tools and techniques can be developed to help manufacturing firms think through this question?

Current research raises questions about how profitable the shift to services is for high value manufacturing firms.

- What types of service strategy facilitate the achievement of high value over product lifecycles?

2 Strategies and Measures for High Value Manufacturing:

- Thinking about high value manufacturing requires manufacturing firms and those supporting them to adopt a broad definition of manufacturing. Research should seek to establish the components and characteristics of a conceptual framework for high value manufacturing. We should also explore how such a framework can be used by manufacturers and policymakers as they formulate strategies for high value manufacturing.
- What are the components/characteristics of a framework for high value manufacturing – building on the four TSB pillars? How can manufacturers use such a framework as they seek to clarify their strategy?
- What are the most appropriate measurement systems for high value manufacturing and the global value systems that support them? Answering this question requires measures to be developed that can track the value-in-use delivered to customers by multiple organisations cooperating across a global value system.
- What are the best migration strategies for manufacturing firms seeking to adopt a strategy of high value manufacturing?

3 Architecture, Modelling and Design of High Value Manufacturing Systems:

- What are the most successful archetypes for high value manufacturing in a context of global value systems? What are the relative advantages and risks of these different archetypes? Who benefits most from them as a result and what are the distinguishing capabilities of those firms that are able to appropriate value from global value systems?
- What are the appropriate modelling methods for high value manufacturing and global value systems, especially in the context of long term capability based contracts? How can high value manufacturers entering into long-term use or capability based contracts manage risk and model future business performance?
- How can technology best be exploited for the development of the global value systems that underpin high value manufacturing?

4 Skills for High Value Manufacturing:

- What are the implications of high value manufacturing for education systems from basic to lifelong learning? What skills and capabilities should we expect managers of high value manufacturing firms to have?

introduction

"Manufacturing matters. It creates wealth, sustains jobs and is central to our economic success. It has been the foundation of our strength as a trading nation in both the past and the present." (BERR/DIUS, 2008).

In September 2008 BERR and DIUS published a new manufacturing strategy for the UK which highlighted that:

- The UK is the world's 6th largest manufacturing country in the world.
- Manufacturing adds over £150bn to the economy (2006).
- Manufacturing in the UK accounts for a seventh of total output and generates 50% of all UK exports.
- Manufacturing directly employs almost 3 million people.
- Manufacturing accounts for three-quarters of business R&D.

Underlying these headline grabbing figures is a more subtle story. Official data suggests that manufacturing output has remained relatively stable in recent years (see Figure 1), while manufacturing employment has been declining since 1998 (see Figure 2).

Figure 1: Manufacturing Output (Index 2003=100)

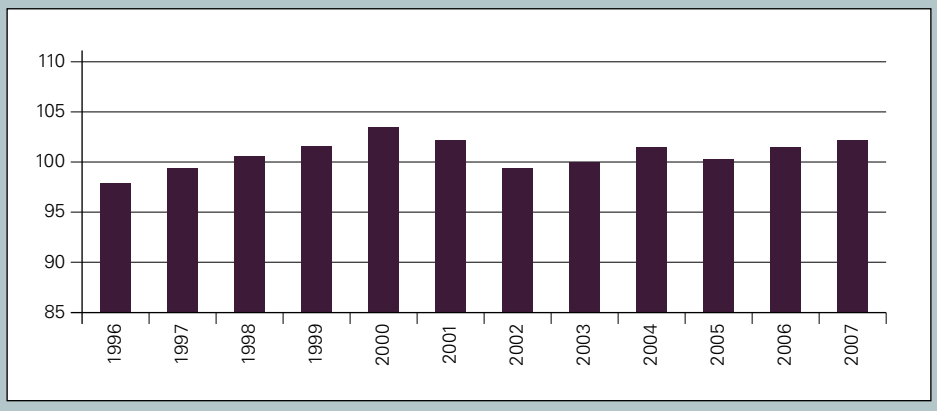
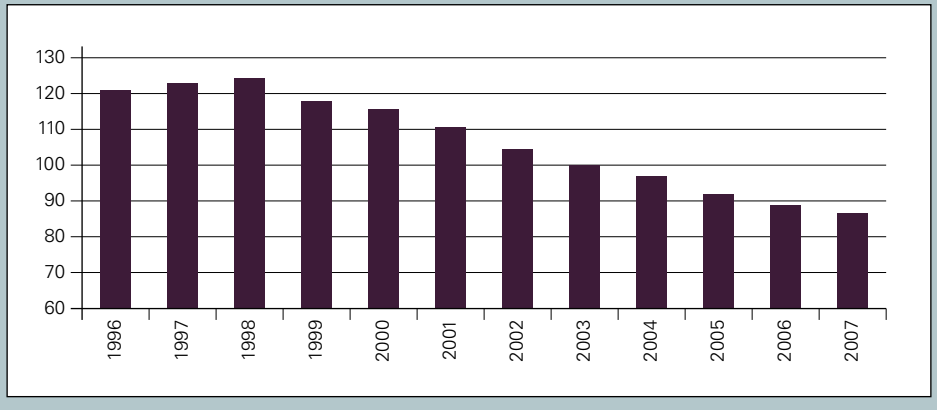
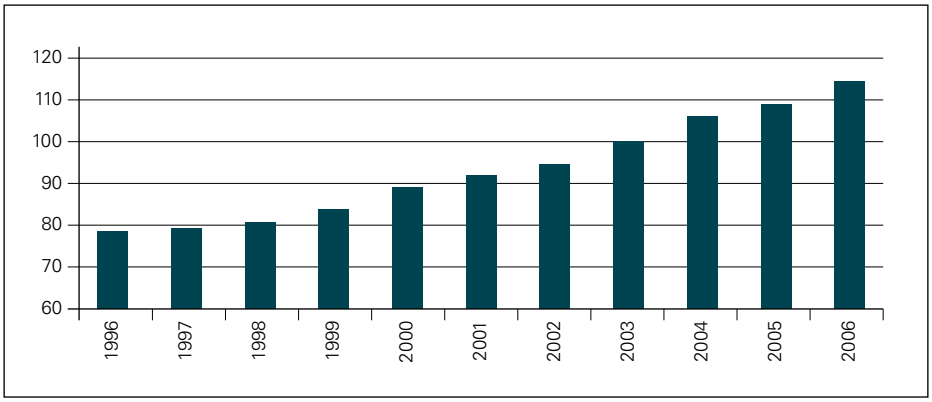


Figure 2: Manufacturing Employment (Index 2003=100)



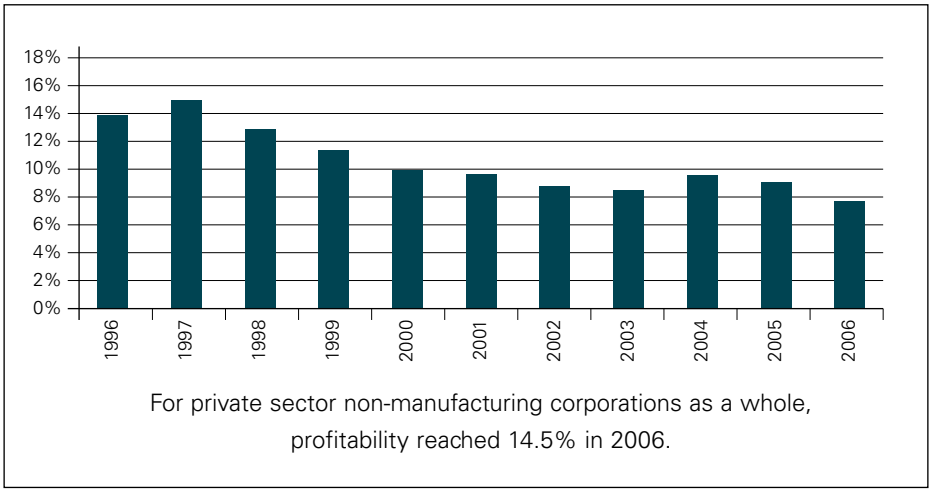
The combination of stable output coupled with falling employment, often due to improved technology, results in increasing labour productivity (see Figure 3) – a factor often missed in reports that tend to focus on the decline of UK manufacturing.

Figure 3: Manufacturing Productivity (Output per hour, Index 2003=100)



While the labour productivity story is a positive one the same cannot be said of UK manufacturing profitability, which appears to be declining. In 2006 UK manufacturing profitability was 7.8% (see Figure 4). This contrasts with non-manufacturing profitability (agriculture and services), which in 2006 was 14.5%.

Figure 4: Manufacturing Profitability (% net rate of return)



For private sector non-manufacturing corporations as a whole, profitability reached 14.5% in 2006.

There are several explanations for the relatively low level of UK manufacturing profitability – not least the emergence of alternative low cost sources of supply. Of course, such low cost sources of supply affect every developed economy, not just the UK – hence the flurry of manufacturing strategies and policy papers arguing that firms in developed economies need to move up the value chain and compete on the basis of value delivered rather than on the basis of cost (Delbridge et al, 2006; OECD, 2007; Porter and Ketels, 2003).

One recent UK report – Lord Sainsbury's Review – the Race to the Top (Sainsbury, 2007) argues that "in 1980 less than one-tenth of manufacturing exports came from the developing world. Today it is almost one third and in 20 years' time it is likely to be one-half". Clearly this growing international manufacturing capacity has significant consequences – if 50% of manufacturing exports will be delivered by firms based in developing countries within 20 years, then firms in developed economies need to decide how they will respond. Both the Department for Business Enterprise and Regulatory Reform and the Department for Innovation Universities and Skills, as well as many other commentators, believe that the answer lies in innovation. The core argument is that innovation can lead to the design and development of high value products and services, as well as instigating change that enables organisations to do that which they already do better (Delbridge et al, 2006; DIUS, 2008; DTI, 2003).

Recognising the broad nature of these calls, delivery focussed organisations such as the Technology Strategy Board have sought to translate high level strategies into specific activities. In their strategy the Technology Strategy Board argues that the future of manufacturing in the UK is one where…

The core argument is that innovation can lead to the design and development of high value products and services…

- Its composition will continue to move away from the traditional areas, towards high-value, knowledge intensive goods.
- The emphasis of activities will not just be on production, but will embrace provision of lifetime service, around a manufactured product.
- Continued automation of physical and information processes will drive efficiency improvement.
- The business model will be increasingly specialised, with outsourcing of noncore activities.
- The value chain will be increasingly complex and international resulting in global value networks (TSB, 2008).

It is in this context that AIM Research, the Technology Strategy Board, the Economic and Social Research Council (ESRC) and the Engineering and Physical Sciences Research Council (EPSRC) brought together a group of academics, policymakers and practitioners to debate high value manufacturing (see Appendix A for a list of attendees). Participants in the discussion were invited to address four broad questions:

- What does high value manufacturing mean to the UK, particularly in the context of global value systems?
- How can UK firms configure international global value systems that are competitive?
- What challenges do UK manufacturing firms face in creating global value systems?
- What research is needed to address these challenges?

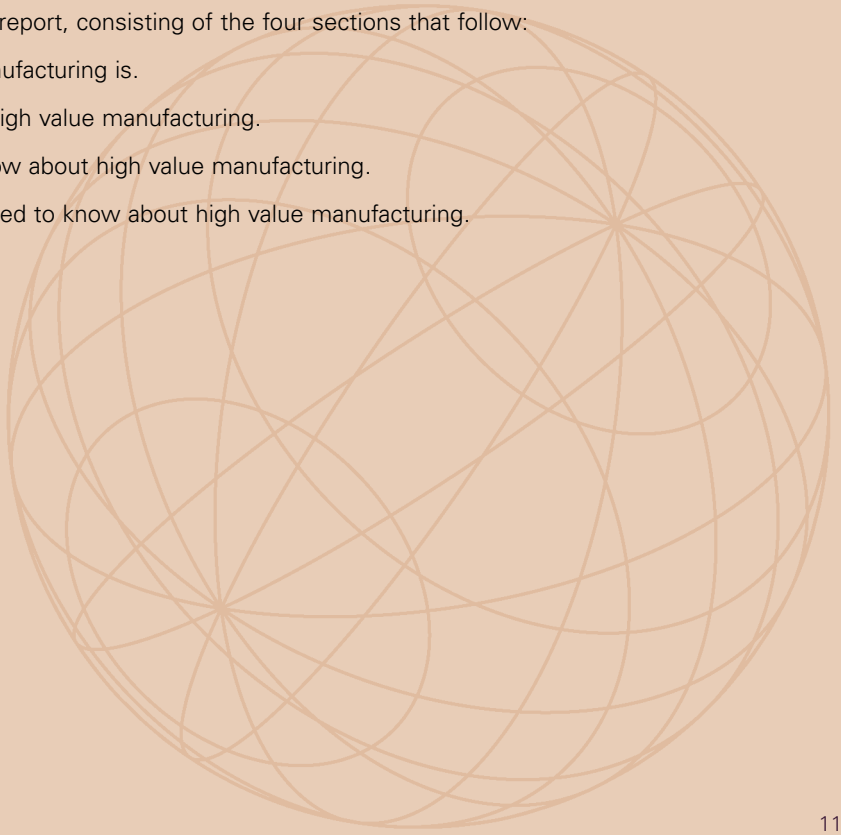
These discussions were captured by AIM Scholars, each working with one of four roundtable groups. The AIM Scholars subsequently reviewed the discussion notes and developed a structure for this report, consisting of the four sections that follow:

1 Clarifying what high value manufacturing is.

2 Understanding the drivers of high value manufacturing.

3 Exploring what we already know about high value manufacturing.

4 Establishing what more we need to know about high value manufacturing.



what is high value manufacturing?

While there was general consensus amongst the workshop participants on the pressures facing UK manufacturing companies, particularly the need to combat declining profitability of the sector and the growth of exports from developing nations (see previous section), there was considerable variety in the perspectives and terminology used to describe what high value manufacturing is. This variety may be explained, in part, by four main issues:

- The difficulty in articulating the changing context of manufacturing.
- The blurring of the boundary between service and manufacturing.
- An increasing focus on 'value' to customers – often referred to as a consumption rather than production mindset.
- The global distribution of production and the varying mechanisms by which they are integrated.

Traditionally manufacturing has been defined as the transformation of raw material into a finished product – with products sometimes being crudely defined as 'something you can drop on your toe'. In reality, however, the boundaries between products and services are blurred and many manufacturers offer services in support of their products.

In some cases these additional services allow firms to access new revenue streams, although recent research questions how profitable these additional revenue streams are (Neely, 2008). While this product/service mix is broadly recognised, the tendency to delineate manufacturing and service firms continues to be driven by classification schemes (e.g. the Standard Industrial Classification SIC), fuelled by a requirement to report economic activity. Additional confusion is presented by the terms 'production' and 'manufacturing', although the latter is usually seen as encapsulating the former.

At one level this confusion can be explained as a boundary issue. Further confusion results because of the variety of currently in vogue service concepts, for example, servitization, product-service systems, experiential services, services sciences and service-dominant logic (IfM/IBM, 2008). Sectoral emphasis compounds the confusion. While the healthcare domain, for example, is recognised as a 'service context', many healthcare processes rely heavily on manufactured products. And some would argue that healthcare operations exhibit some similarity with 'repair and overhaul' in manufacturing contexts. This example emphasises a requirement to move beyond outmoded classification schemes and to identify more appropriate frameworks which characterise manufacturing-service contexts.

In essence these popular themes highlight the potential benefits that may be embraced by manufacturing firms which engage in services.

As manufacturing companies increase their emphasis on additional service opportunities for value generation and revenue growth, the delineation of manufacturing and service becomes increasingly difficult. As Rust (1998) indicates (from a service perspective): "the typical service research article documented ways in which services were different from goods… It is time for a change. Service research is not a niche field characterised by arcane points of difference with the dominant goods management field". A poignant issue facing UK industry, whether manufacturing or service, is therefore to explore ways in which operations can be configured to create value through combinations of goods and service offerings. Given this shift in orientation it comes as no surprise that concepts such as product-service systems (Goedkoop, 1999), servitization (Vandermerwe and Rada, 1988) and high value manufacturing have all emerged and gained popularity. In essence these popular themes highlight the potential benefits that may be embraced by manufacturing firms which engage in services. Regardless of the language used, however, the unifying theme is that of value creation – this in turn opens up the question of what is value.

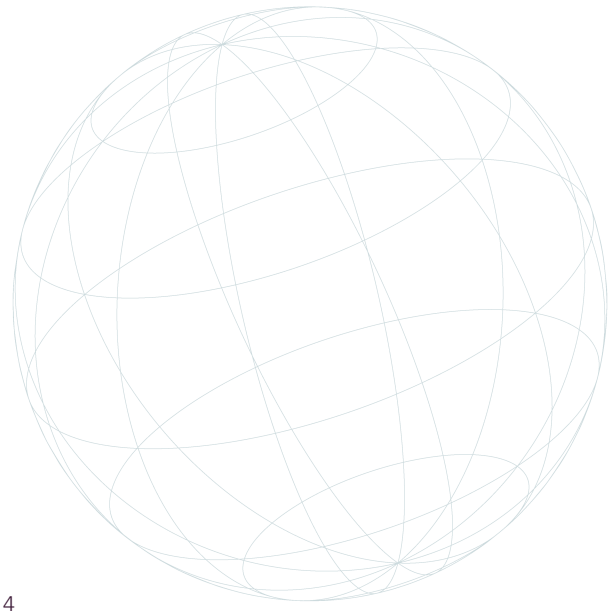
What is Value in the Context of High Value Manufacturing?

Vargo and Lusch (2004) have explored the concept of value in their work on service-dominant logic (SDL) – an additional competing term. Rooted in the concept of economic exchange, the central arguments are: a need for an integrative view of service and product; a shift from a producer perspective to the utilisation and consumer perspective (see Gummesson, 1995) and the idea that value is co-created. Rather than recipients of manufactured products, customers are 'resources' who participate as co-producers in production, actively taking part in product development (Grönroos, 2007). Indeed, in some contexts, customers have responsibilities to ensure the successful delivery of services – e.g. adhering to maintenance schedules for large capital equipment. Hence it becomes of interest for the manufacturer to monitor the user to confirm that they stick to their side of the bargain.

While co-production has become a popular characteristic in distinguishing service contexts, it is also, arguably a characteristic observable in a manufacturing context. Engineer-to-Order manufacturing companies, for example, engage with customers in co-design and co-specification of product. The 'product' from a service-dominant logic perspective, however, is an 'appliance' through which end customers obtain value. This customer focused value has received attention in research associated with product-service systems and the servitization of manufacturing, which emphasises issues of value-in-use as well as value from economic exchange. Often firms appear to focus on the latter – value from economic exchange. It is clear however, from both the statistical trends in output (Section 1) and the Technology Strategy Board's strategy, that high value manufacturing will require firms to focus on the former – value-in-use. Furthermore, given the changing context of manufacturing, a broad definition of value (i.e. one encompassing a wide variety of stakeholders) will have to be adopted. As Figure 5 shows there are multiple actors who might extract value from any value proposition offered by a firm.

Figure 5: Stakeholder perspectives on value (from Livesey, 2006)

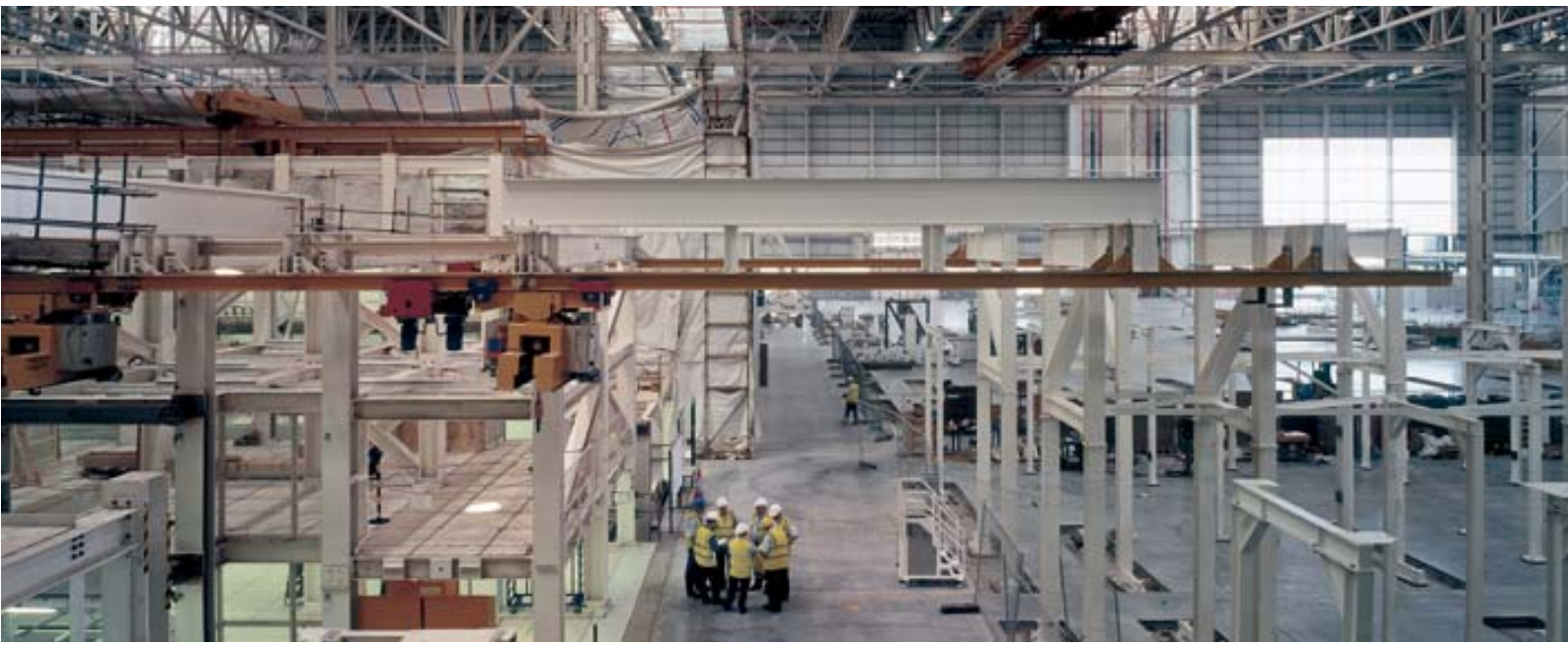
	Financial	Strategic	Social
Country	• GDP impact • Tax payed	• Sustainable employment • Intellectual capital development • Employee capability development	• Minimal environmental impact
Investors	• Return adjusted for risk • Long term growth	• Adaptability, sustainability	• Acts ethically
Employees	• Pay, wages • Funding of retirement	• Lifelong learning • Opportunities for growth	• Personal development • Social interaction • Work-life balance



High Value Manufacturing Defined

Previous work has indicated that "there is no simple definition of high value manufacturing" and that "high value manufacturers can create value… (through)… unique production processes, high brand recognition, rapid delivery times, or highly customised services" (Livesey, 2006). The Sainsbury review (2007:15) provides a more general description of the types of companies that can thrive in a race to the top: they "must increase their productivity in existing industries by improving product quality, adding new and attractive features, using new product technology and raising production efficiency" and "develop the products and services that command premium prices in international markets". Notwithstanding these requirements high value manufacturers will need to articulate their strategies around value propositions to stakeholder groups. For this reason this report defines high value manufacturers as follows:

High value manufacturers are manufacturing firms that do not compete primarily on cost. Instead they deliver value for one or more of their stakeholder groups by contracting for capability, delivering product/service innovation, establishing process excellence, achieving high brand recognition and/or contributing to a sustainable society.

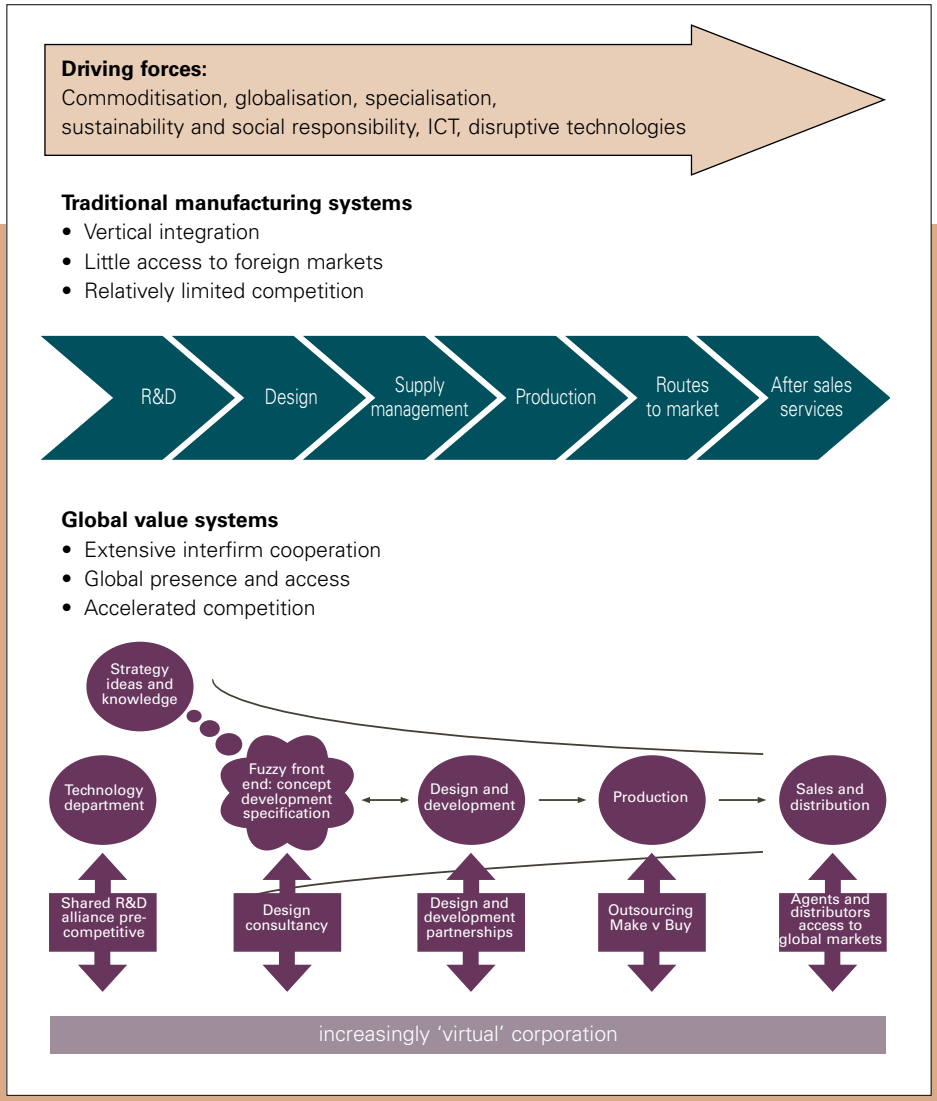


This definition has been formulated to encompass a plethora of high value manufacturing contexts for a range of stakeholders, and therefore forms a reference point for research which attempts to address the economic context highlighted in Section 1. The following section (Section 3) provides an in-depth review of specific drivers of high value manufacturing, reinforcing the need for further developments in both research and practice.

what are the drivers of high value manufacturing?

The previous section defines high value manufacturing in terms of contribution to various stakeholders. This section summarises the workshop discussions and describes five structural forces affecting today's competitive landscape, which have significant implications for high value manufacturing: commoditisation, globalisation, specialisation, sustainability and technology. Together these forces create challenging conditions for manufacturing firms, resulting in global value systems that are increasingly fragmented and geographically dispersed (see Figure 6). Fragmented and geographically dispersed global value systems require cross-organisational and cross-border co-ordination and integration, both of which place demands on the planet's ecosystem. Couple this with demographic changes – both in terms of population growth and population aspirations – and it is easy to see why there are growing concerns about the pressure on the planet's eco-system.

Figure 6: Driving forces and structural changes



Adapted from; Sainsbury Review, 2007; Fraser, Farrukh and Gregory, 2003

Commoditisation: The Fundamental Force

In an open market, companies compete against each other to satisfy the customer's need. New products and services with distinctive features may meet little competition in the early stages of the product lifecycle, but they will gradually lose advantage as product/service differentiation is diffused into the market and imitated by others. As a result, "products and services that are currently regarded as among the most innovative and experimental ultimately end up as commodities that can be produced anywhere and by many producers" (OECD, 2007).

The commoditisation process erodes a firm's competitive position and leads to competition primarily based on price. In order to avoid the commoditisation trap, companies have to keep a constant flow of innovation, not only in terms of what is offered to the customer, but also in how products and services are designed, produced, delivered and marketed.

The Impact of Globalisation on Value Chains

The market for manufacturing firms is increasingly globalised due to a reduction in trade barriers and advances in transport and communication technologies (Sainsbury, 2007). For many manufacturers, particularly those competing on cost, this leads to intense competition. Globalisation, however, also provides significant development opportunities. It provides access to an expanded customer base and uncovers new sources of supply in raw materials and intermediate products and services. More than ever before, manufacturers find themselves an integral part of global value systems (OECD, 2007).

Globalisation accelerates the diffusion of innovation and the commoditisation process, thereby driving an ever increasing pace of innovation. The emergence of low-cost economies, notably Brazil, India, China and Eastern Europe, intensifies competition in low value-added, labour-intensive products. In response, companies in developed countries often increase their degree of automation, thereby reducing their reliance on labour. Firms also decide to relocate or subcontract part, if not all, of their production to low cost countries. At the same time, however, manufacturers in low-cost economies are searching for opportunities to upgrade into high value-added areas. For instance, Chinese companies such as Huawei and ZTE have established themselves as leading players in the telecommunication equipment sector.

As well as providing new sources of supply, developing countries also open up their enormous consumer and industrial markets to established manufacturers. Economic development in emerging economies has resulted in the demand for increasingly sophisticated products and services that domestic manufacturers may not be able to offer. Furthermore, globalisation provides organisations with access to resources, capabilities and skills which provide significant competitive opportunities. To encourage the inflow of foreign investment, industrial clusters and research centres have been established and developing countries are rapidly growing their indigenous skill base. In China, for example, there were over 1.5 million science and engineering graduates in 2006 and the number of new enrolment continues to grow each year.

The Prevalence of Specialisation

Since the division of labour was first articulated by Adam Smith over 200 years ago, specialisation has been a common practice in virtually all industries. The result of organisational specialisation where organisations choose to concentrate on particular parts of the value chain is the fragmentation of manufacturing (Sainsbury, 2007: 13). Enabled by new communication technologies and modern relationship practices, specialisation allows companies to gain access to capacity and expertise not available internally. The need for task specialisation intensifies as products and services become ever more complex. Even in areas previously considered as specialisms, finer division of labour takes place over time.

Companies can choose to compete in certain parts of a value chain and develop strategic partnerships through which the total value proposition is formulated. As a consequence of specialisation firms face the challenge of integration necessitated by interdependencies and a fragmented value system. When coupled with the globalisation trends discussed earlier, competition now takes place between global value systems, which are integrated through cross-border, cross-organisation co-ordination.

Sustainability and Social Responsibility: Newer Dimensions

A growing trend is for society to re-examine and adjust practices with regard to sustainability (Stern, 2006). Environmental pressure and resource consumption are set to grow – compounded by economic success in developing countries and population growth. In response to global warming and its likely consequences of climate change, for example, UK has committed to cut carbon emissions by 60% from the 1990 level by 2050. As an important stakeholder of the response, manufacturers play a crucial part in developing renewable energy supply, improving energy efficiency and reducing greenhouse gas emissions (EEF, 2005). Manufacturers also play a critical role in reducing the waste of natural resources and the elimination of pollution. In addition, consumers expect retailers and manufacturers to behave responsibly in terms of fair trade and poverty reduction. Companies who proactively act on concerns over sustainability and social responsibility are likely to gain competitive advantage and achieve benefits from leading innovations, such as low-carbon products and services (EEF, 2008).

Advances in ICT and Disruptive Technologies

Clearly developments in technology may ease some of the challenges outlined in the previous sections. Information and communication technologies, for example, are changing the way people and organisations work. Together with modern transportation technologies, we are seeing a reduction in the time and cost required to carry out international transactions. Internet based technologies also create new markets and provide additional channels for conventional products and services. Disruptive technologies, such as nanotechnology and biotechnology, also have the potential to revolutionise products and processes that affect our lives (House of Commons 2003; Royal Society, 2004). The challenge for high value manufacturing firms will be to capitalise on new technologies and the opportunities they afford (House of Commons, 2004), using them to address the plethora of competitive, global, and environmental priorities.

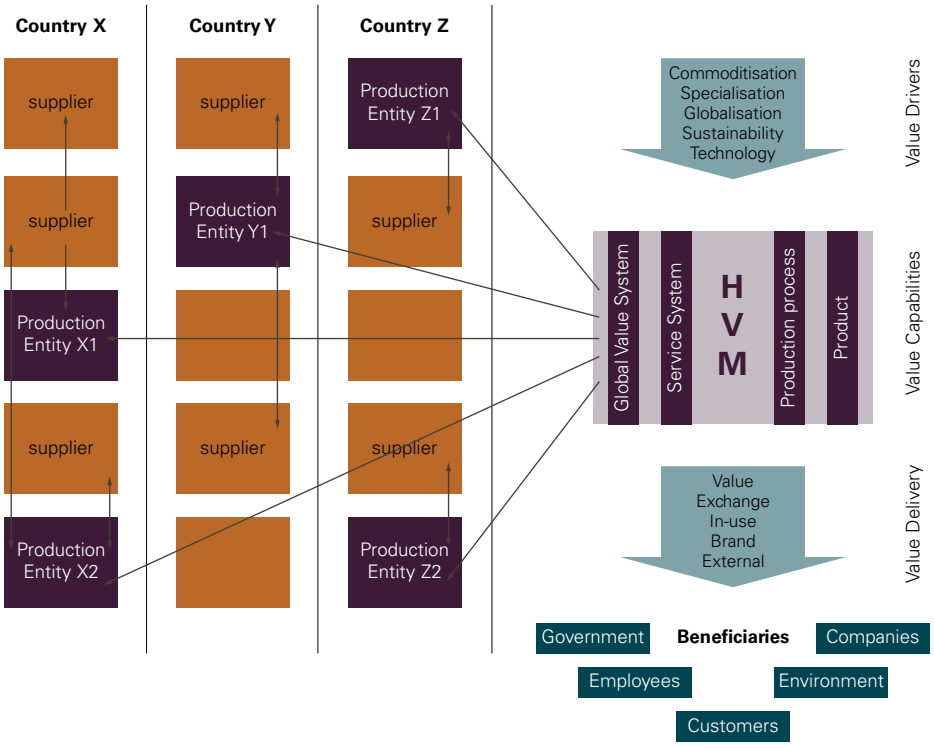
what do we know about high value manufacturing?

The previous section discussed long-term trends affecting UK manufacturing and its competitiveness, and outlined five structural forces: commoditisation, globalisation, specialisation, sustainability and technology identified by the workshop participants. In light of the significant challenges and opportunities facing manufacturing companies this section outlines what is already known about high value manufacturing and how countries are responding to the challenges high value manufacturing poses.

High value manufacturers operate in a dynamic competitive environment, but often firms are constrained by legacy systems…

The first point to note is that the drivers outlined in the previous section are resulting in a changing competitive landscape for manufacturing firms. Figure 7 illustrates this, highlighting the emergence of global value systems, the members of which have to co-ordinate and orchestrate their activities to deliver stakeholder value. In this figure firms X1, X2, Y1, Z1 and Z2 all have to co-ordinate their activities as part of a global value system to deliver value to their beneficiaries.

Figure 7: The inter-connected nature of global value systems



Research challenge 1 from the workshop:

High value manufacturers operate in a dynamic competitive environment, but often firms are constrained by legacy systems, structures and relationships – including those introduced by external actors such as regulators and legislators. Understanding how the global competitive environment that UK manufacturers face will change and what the implications of these changes will be is essential.

The Technology Strategy Board's strategy for high value manufacturing raises a fundamental question for global value systems such as the one illustrated in Figure 7, namely *"how can efficient synchronisation of global value systems lower environmental impact and offer economic advantage to UK manufacturing firms"?*

This question is so important because we know that product and process-based manufacturing advantage proves relatively transient because it is easy for competitors to imitate (Hayes and Wheelwright, 1984). One of the consequences of this is that many manufacturers are now looking for new ways of delivering value through the integration of services – hence the Technology Strategy Board pillar: service systems.

Research challenge 2 from the workshop:

Current research raises questions about how profitable the shift to services is for high value manufacturing firms. A series of macro and micro studies have highlighted that it is more difficult to achieve higher profitability through services than might originally be assumed. What is the appropriate balance for high value manufacturing firms between revenues from services and revenues from production? What practical tools and techniques can be developed to help manufacturing firms think through this question?

As discussed previously economic theories of value distinguish between exchange/economic value and value-in-use. Exchange value is realised when a product-service is sold, in essence as a one time transaction. Value-in-use is value as perceived by the customer. It is a function of the customer's perception of the usefulness of the product-service offer over time. Previous research suggests that value-in-use is influenced by factors such as superior quality, aesthetics, functionality and service delivery (Woodruff and Gardial, 1996). What is not clear is the appropriate dimensions and mechanisms for assessing value in a high value manufacturing context.

Research challenge 3 from the workshop:

What are the most appropriate measurement systems for high value manufacturing and the global value systems that support them? Answering this question requires measures to be developed that can track the value-in-use delivered to customers by multiple organisations cooperating across a global value system.

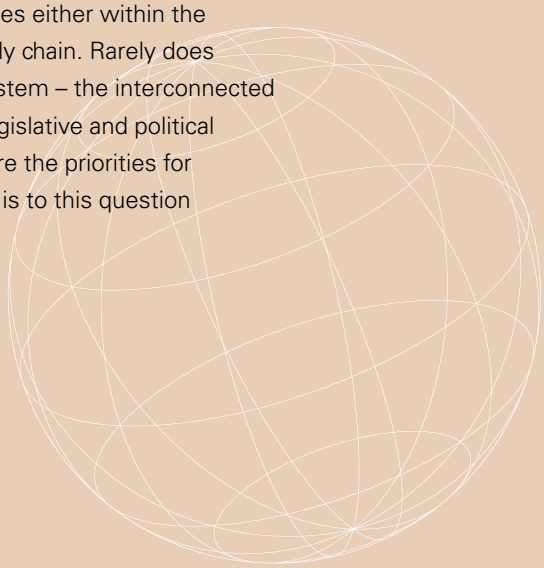
Moving beyond the question of value it is important to recognise that high value manufacturing is not a completely new concept; indeed it has been researched in various guises for some time. First there has been significant work over the years on manufacturing and operations strategy – this work explores questions of the efficacy and impact of different manufacturing and operations strategies (Flynn and Flynn, 2004), as well as questions of how to design and deploy manufacturing strategies (Hayes and Wheelwright, 1984; Skinner, 1985). As with other research challenges, however, there is a need to explore how these existing frameworks and methodologies translate to the context of high value manufacturing, especially given the fragmented nature of global value systems (Shi and Gregory, 1998).

Research challenge 4 from the workshop:

Thinking about high value manufacturing requires manufacturing firms and those supporting them to adopt a broad definition of manufacturing. Research should seek to establish the components and characteristics of a conceptual framework for high value manufacturing. We should also explore how such a framework can be used by manufacturers and policymakers as they formulate strategies for high value manufacturing.

At a more specific level, researchers have explored concepts associated with high value manufacturing: product-service systems; the servitization of manufacturing. A key issue related to research on product-service systems is the distinction between product ownership and product use (Tukker, 2004). Traditionally customers have purchased products and in doing so have acquired ownership rights over the product. Increasingly, however, manufacturing firms are offering value propositions based on use or the sale of capability. Business models that rely on leasing and/or rental, as well as capability based contracts in the defence industry, for example, both centre on the delivery of capability rather than a product. Issues of risk and performance modelling become central in such contracts, especially when manufacturers enter into long term, sometimes multi-year, agreements.

Much of the research that has been completed to date focuses either within the boundaries of the firm or across members of the same supply chain. Rarely does manufacturing research consider the broader global value system – the interconnected set of supply chains that are grounded in wider economic, legislative and political contexts. Given this context an important question is what are the priorities for improving our understanding of high value manufacturing? It is to this question that we turn in the next section.



what do we need to know about high value manufacturing?

In response to structural changes in the global economy, manufacturers in the UK have to be competitive in domestic and international markets and in existing and new industries. With significant benefits to the economy and society, the UK must remain attractive to domestic and foreign investment. This leads to two separate, but interlinked questions:

- What should UK manufacturers do in response to current and future trends?
- What should the UK government do in order to enable the above strategies?

Clearly there is a great deal of work underway in areas such as R&D investment, skill development, business support and public procurement (DIUS, 2008; Sainsbury, 2007; TSB, 2008). Many of these policies are designed to encourage technology innovation and build a favourable environment for business. In comparison, there is arguably less support for strengthening UK manufacturers' capabilities in technology exploitation, service systems and global value systems. More research is needed to capture leading practices and to disseminate knowledge in these areas.

Creating a Context and Framework for High Value Manufacturing

The Technology Strategy Board strategy identifies products, processes, service systems and global value systems as four pillars of high value manufacturing (TSB, 2008). Synthesising these pillars with the drivers identified at the workshop may result in a more complete picture of high value manufacturing.

Research challenge 5 from the workshop:

What are the components/characteristics of a framework for high value manufacturing – building on the four TSB pillars? How can manufacturers use such a framework as they seek to clarify their strategy?

Clearly there are multiple routes to developing capability as a high value manufacturing firm given a variety of different competitive priorities. Conventional classification schemes, which are often based on sector and size, may have limited explanation power in this context. Accordingly, further research is needed to group companies based on the likelihood that they take specific routes to high value manufacturing.

Research challenge 6 from the workshop:

What are the best migration strategies for manufacturing firms seeking to adopt a strategy of high value manufacturing?

Architecture of Global Value Systems

A key challenge, highlighted in this report, is the fragmented nature of global value systems which emerge from globalisation and specialisation. As new ideas in technology emerge, manufacturers have to identify effective ways of exploiting these developments for commercial gain. To improve the rate of success, it is crucial to take a balanced view of market trends and emerging technologies. And it is important to consider current and future states of skill supply, infrastructure provision and value systems, all at a global level. We need roadmaps that indicate how new ideas might be best exploited.

Research challenge 7 from the workshop:

How can technology best be exploited for the development of the global value systems that underpin high value manufacturing?

In the development of a global value systems architecture it is important to establish the division of labour between members of global value systems and examine its connection to the distribution of value added. For instance, global value systems can be examined through value chains and supply networks at various levels from the perspective of small, medium and large companies.

Research should also shed light on the evolution patterns of global value systems.

Research challenge 8 from the workshop:

What are the most successful archetypes for high value manufacturing in a context of global value systems? What are the relative advantages and risks of these different archetypes? Who benefits most from them as a result and what are the distinguishing capabilities of those firms that are able to appropriate value from global value systems?

An integral part of global value systems is the development of services around and beyond hardware and software products. As the Technology Strategy Board's recent strategy for high value manufacturing recognises there is a need for more work on whole life planning. This was re-enforced by workshop participants.

Research challenge 9 from the workshop:

What types of service strategy facilitate the achievement of high value over product lifecycles?

Modelling and Design of Global Value Systems

To put the architecture into practice and to support decision making processes, modelling, analysis and simulation methods for global value systems are required. These methods should facilitate scenario analyses which mitigate risk and inform the strategic trajectories of firms.

Research challenge 10 from the workshop:

What are the appropriate modelling methods for high value manufacturing and global value systems, especially in the context of long term capability based contracts? How can high value manufacturers entering into long-term use or capability based contracts manage risk and model future business performance?

Development of Organisational Capabilities and Individual Skills

The skill base has to be responsive to the need of manufacturing industries. Current efforts in skill development are focused on specific elements of value systems, notably design and production. Decisions on the UK's role in global value systems have additional implications for the education system. It requires skill sets to support technology exploitation and the development of service strategies and operations. There is also demand for management who are capable of thinking and acting in a global context.

Research challenge 11 from the workshop:

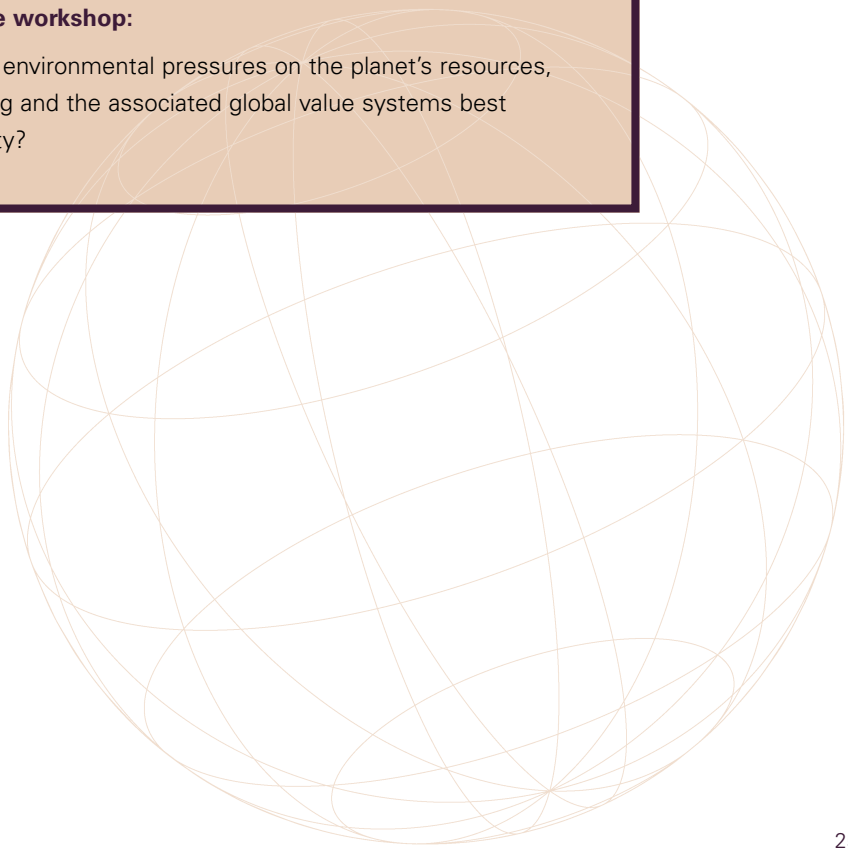
What are the implications of high value manufacturing for education systems from basic to lifelong learning? What skills and capabilities should we expect managers of high value manufacturing firms to have?

Manufacturing in a Sustainable Society

As the Technology Strategy Board's strategy for high value manufacturing recognises manufacturing has a leading role to play in reducing our impact on the environment. In addition to searching for alternative energy sources and improving energy efficiency, manufacturers are also in a good position to influence the full cycle of resource consumption from technology development and product design through production processes to distribution, lifecycle support, end-of-life disposal and/or recycling.

Research challenge 12 from the workshop:

Given increasing concerns about environmental pressures on the planet's resources, how can high value manufacturing and the associated global value systems best contribute to a sustainable society?



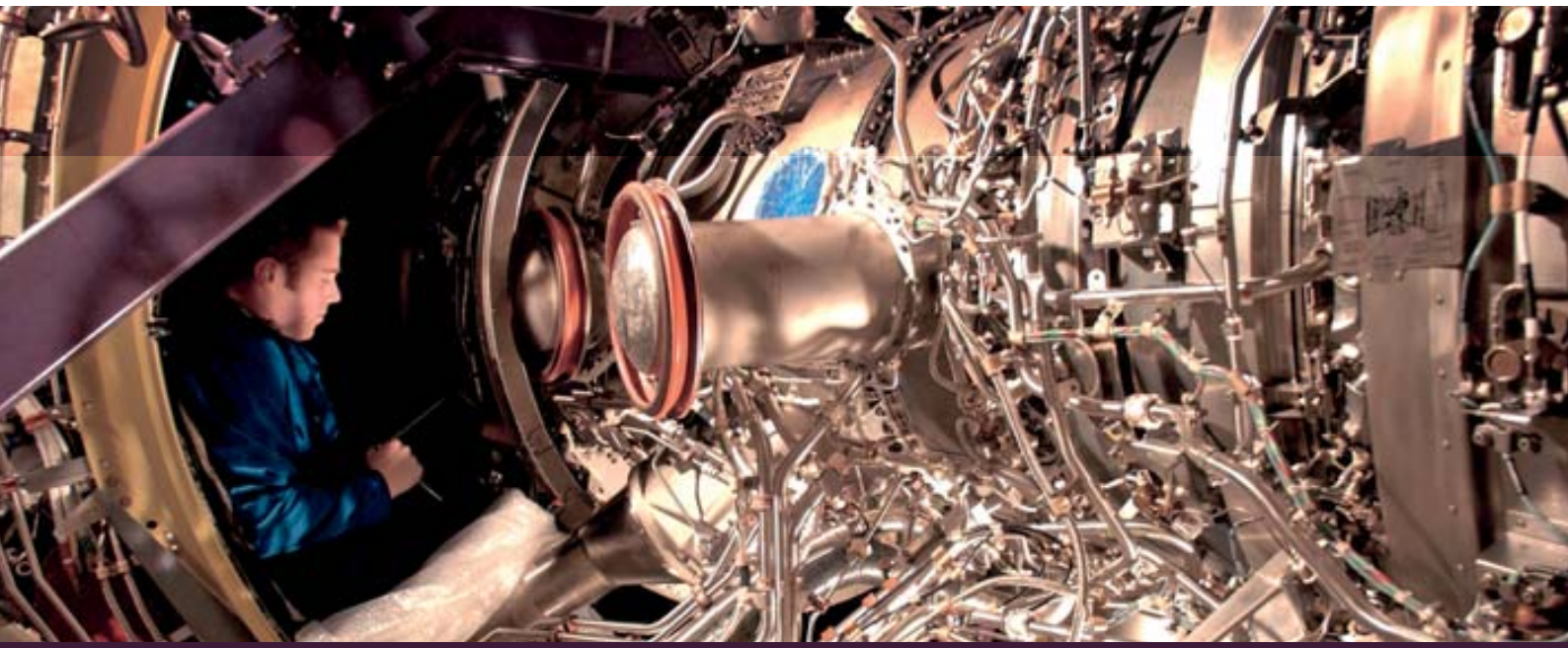
concluding statement – delivering on the promise

The previous section identifies 12 challenges for high value manufacturing. These group into four broad categories – (i) evolving context and frameworks for high value manufacturing, (ii) strategies and measures for high value manufacturing, (iii) architecture, modelling and design of the global value systems that enable high value manufacturing and (iv) skills for high value manufacturing.

Under these broad headings, specific sub-questions are proposed:

1 Evolving Context and Frameworks for High Value Manufacturing:

- High value manufacturers operate in a dynamic competitive environment, but often firms are constrained by legacy systems, structures and relationships – including those introduced by external actors such as regulators and legislators. Understanding how the global competitive environment that UK manufacturers face will change and what the implications of these changes will be is essential.
- Given increasing concerns about environmental pressures on the planet's resources, how can high value manufacturing and the associated global value systems best contribute to a sustainable society?



- Current research raises questions about how profitable the shift to services is for high value manufacturing firms. A series of macro and micro studies have highlighted that it is more difficult to achieve higher profitability through services than might originally be assumed. What is the appropriate balance for high value manufacturing firms between revenues from services and revenues from production? What practical tools and techniques can be developed to help manufacturing firms think through this question?
- What types of service strategy facilitate the achievement of high value over product lifecycles?

2 Strategies and Measures for High Value Manufacturing:

- Thinking about high value manufacturing requires manufacturing firms and those supporting them to adopt a broad definition of manufacturing. Research should seek to establish the components and characteristics of a conceptual framework for high value manufacturing. We should also explore how such a framework can be used by manufacturers and policymakers as they formulate strategies for high value manufacturing.
- What are the components/characteristics of a framework for high value manufacturing – building on the four TSB pillars? How can manufacturers use such a framework as they seek to clarify their strategy?
- What are the most appropriate measurement systems for high value manufacturing and the global value systems that support them? Answering this question requires measures to be developed that can track the value-in-use delivered to customers by multiple organisations cooperating across a global value system.
- What are the best migration strategies for manufacturing firms seeking to adopt a strategy of high value manufacturing?

What are the best migration strategies for manufacturing firms seeking to adopt a strategy of high value manufacturing?

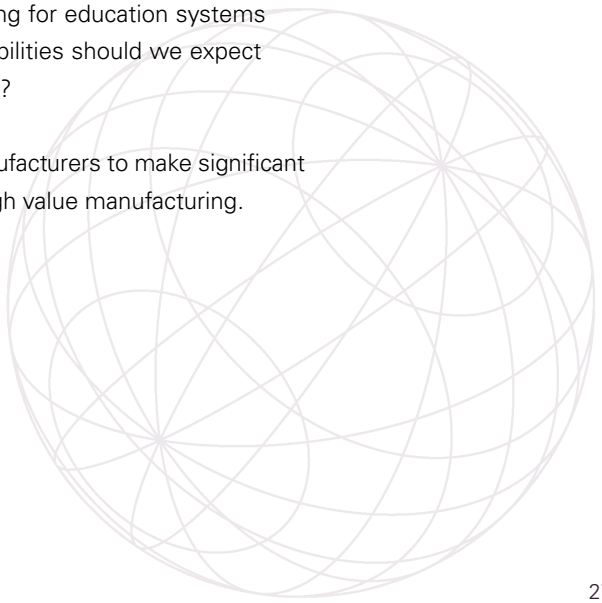
3 Architecture, Modelling and Design of High Value Manufacturing Systems:

- What are the most successful archetypes for high value manufacturing in a context of global value systems? What are the relative advantages and risks of these different archetypes? Who benefits most from them as a result and what are the distinguishing capabilities of those firms that are able to appropriate value from global value systems?
- What are the appropriate modelling methods for high value manufacturing and global value systems, especially in the context of long term capability based contracts? How can high value manufacturers entering into long-term use or capability based contracts manage risk and model future business performance?
- How can technology best be exploited for the development of the global value systems that underpin high value manufacturing?

4 Skills for High Value Manufacturing:

- What are the implications of high value manufacturing for education systems from basic to lifelong learning? What skills and capabilities should we expect managers of high value manufacturing firms to have?

Findings answers to these questions will enable UK manufacturers to make significant progress on their journey to delivering the promise of high value manufacturing.



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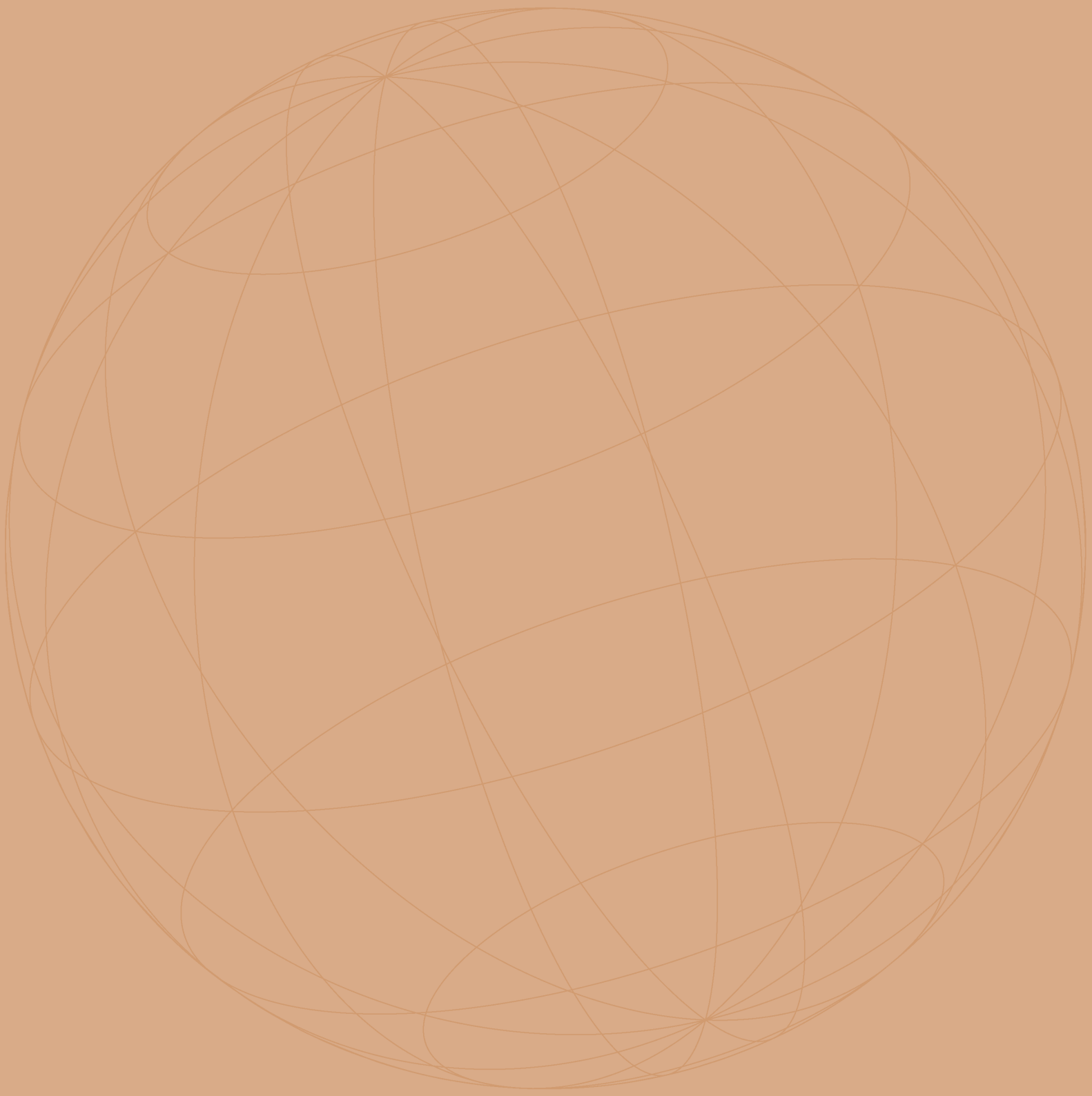
appendix A: attendee list

Tim Baines	Cranfield University
John Bessant	Tanaka Business School
Paul Davies	Thales Aerospace Division
Rick Delbridge	Cardiff Business School
Steve Evans	Cranfield University
Anne Farrow	EPSRC
Peter Flinn	Technology Strategy Board
John Garside	Warwick Manufacturing Group
Joe Greenwell	Ford Motor Company Limited
Mike Gregory	University of Cambridge
Tim Hogan	BERR
Alison Huxley	Design Council
Roger Jeary	Unite
Michael Lewis	University of Bath
Kathryn Magnay	EPSRC
Veronica Martinez	Cranfield School of Management
Kerry Mashford	Ove Arup & Partners Ltd
Paul Mason	Technology Strategy Board
Alan Mayo	BERR
Geoff McFarland	Renishaw PLC
Duncan McFarlane	University of Cambridge
Neil Morgan	Technology Strategy Board
Andy Neely	AIM Research
Eoin O'Sullivan	University of Cambridge
Tim Page	TUC, Economic & Social Affairs
Grant Peggie	DIUS
Guangjie Ren	University of Cambridge
Nick Scott	BERR
Christopher Simpson	Simpson Associates
Jagjit Singh Srai	University of Cambridge
Andi Smart	University of Exeter
Michael Smith	Airbus UK
Martin Stevens	Unimatic Engineers Ltd
Steve Street	IBM (UK) Ltd
Richard Taylor	Hewlett Packard
Bruce Tether	Tanaka Business School
Jonathan Throssell	Rolls-Royce plc
James Watson	BERR
Esther Wilkinson	ESRC



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ISBN 978-1-906087-15-9